CLAIMS

1. A method for measuring dynamic linearity of an acceleration sensor, comprising:

generating an elastic wave pulse in a metal rod (1) by impacting one of end surfaces (2) of the metal rod with each of two round, concentrically located projectiles (8, 10) from a double launch tube (4, 5) independently, and by impacting both projectiles simultaneously or at a prescribed time interval,

using an acceleration sensor (23) provided on the other of the end surfaces (22) of the metal rod to measure an acceleration of the other end surface arising when the elastic wave pulse generated by the impact of the projectiles reflects at the other end surface, and

using an optical measuring instrument (24) to measure and calculate the acceleration of the other end surface,

wherein the dynamic linearity of the acceleration sensor is obtained by comparing in time domain and frequency domain an acceleration output signal of the acceleration sensor when two projectiles are impacted simultaneously or at a prescribed time interval with a sum of acceleration signals obtained when two projectiles are launched separately, measured and calculated by the optical measuring instrument.

2. A method for measuring dynamic linearity of an acceleration sensor, comprising:

generating an elastic wave pulse in a metal rod (1) by impacting one of end surfaces (2) of the metal rod with each of two round, concentrically located projectiles from a double launch tube (4, 5) independently, and by impacting both projectiles simultaneously or at a prescribed time interval,

using an acceleration sensor (23) provided on the other of the end surfaces (22) of the metal rod to measure an acceleration of the other end

surface arising when an elastic wave pulse generated by the impact of the projectiles reflects at the other end surface (22), and

using a strain gauge (25) provided on a side surface of the metal rod to measure strain in the elastic wave pulse produced by the projectile impact,

wherein the dynamic linearity of the acceleration sensor is obtained by comparing in time domain and frequency domain an output signal of the acceleration sensor when two projectiles are impacted simultaneously or at a prescribed time interval with a sum of acceleration signals obtained from strain gauge measurement signals obtained when two projectiles are launched separately.

3. A method for measuring dynamic linearity of an acceleration sensor, comprising:

generating an elastic wave pulse in a metal rod (1) by impacting one of end surfaces of the metal rod with each of two round, concentrically located projectiles (8, 10) from a double launch tube (4, 5) independently, and by impacting both projectiles simultaneously or at a prescribed time interval,

using an acceleration sensor (23) provided on the other of the end surfaces (22) of the metal rod to measure an acceleration of the other end surface arising when the elastic wave pulse generated by the impact of the projectiles reflects at the other end surface, and

measuring strain in the elastic wave pulse produced by the projectile impact at a representative strain gauge (25) location of a plurality of strain gauges affixed axially along a side surface of the metal rod,

wherein the dynamic linearity of the acceleration sensor is obtained by comparing in time domain and frequency domain an output signal of the acceleration sensor when two projectiles are impacted simultaneously or at a prescribed time interval with a sum of acceleration signals obtained from strain gauge measurement signals obtained when two projectiles are

launched separately.

4. A method for measuring dynamic linearity of an acceleration sensor, comprising:

generating an elastic wave pulse in a metal rod (1) by impacting one of end surfaces (2) of the metal rod with each of two round, concentrically located projectiles (8, 10) from a double launch tube (4, 5) independently, and by impacting both projectiles simultaneously or at a prescribed time interval,

using an acceleration sensor (23) provided on the other of the end surfaces of the metal rod to measure an acceleration of the other end surface arising when the elastic wave pulse generated by the impact of the projectiles reflects at the other end surface,

using a strain gauge (25) provided on a side surface of the metal rod to measure strain in the elastic wave pulse produced by the projectile impact, and

calculating a correction to a strain gauge measurement signal corresponding to wave dispersion and attenuation according to elastic wave pulse propagation theory,

wherein the dynamic linearity of the acceleration sensor is obtained by comparing in time domain and frequency domain an output signal of the acceleration sensor when two projectiles are impacted simultaneously or at a prescribed time interval with a sum of acceleration signals obtained from correction calculated signals obtained from the strain gauge when two projectiles are launched separately.

5. A method for measuring dynamic linearity of an acceleration sensor, comprising:

generating an elastic wave pulse in a metal rod (1) by impacting one of end surfaces of the metal rod with each of two round, concentrically located

projectiles from a double launch tube (4, 5) independently, and by impacting both projectiles simultaneously or at a prescribed time interval,

using an acceleration sensor (23) provided on the other of the end surfaces of the metal rod to measure an acceleration of the other end surface arising when the elastic wave pulse generated by the impact of the projectiles reflects at the other end surface,

measuring strain in the elastic wave pulse produced by the projectile impact at a representative strain gauge (25) location of a plurality of strain gauges affixed axially along a side surface of the metal rod, and

calculating a correction to a strain gauge measurement signal corresponding to wave dispersion and attenuation according to elastic wave pulse propagation theory,

wherein the dynamic linearity of the acceleration sensor is obtained by comparing in time domain and frequency domain an output signal of the acceleration sensor when two projectiles are impacted simultaneously or at a prescribed time interval with a sum of acceleration signals obtained from correction calculated signals obtained from the strain gauge when two projectiles are launched separately.

6. A method for measuring dynamic linearity of an acceleration sensor, comprising:

generating an elastic wave pulse in a metal rod (1) by impacting one of end surfaces (2) of the metal rod with each of two round, concentrically located projectiles from a double launch tube (4, 5) independently, and by impacting both projectiles simultaneously or at a prescribed time interval,

using an acceleration sensor (23) provided on the other of the end surfaces of the metal rod to measure an acceleration of the other end surface arising when the elastic wave pulse generated by the impact of the projectiles reflects at the other end surface,

using an optical measuring instrument (24) to measure the acceleration of the other end surface,

using a strain gauge (25) provided on a side surface of the metal rod to measure strain in the elastic wave pulse produced by the projectile impact, and

calculating a correction to a strain gauge measurement signal corresponding to wave dispersion and attenuation according to elastic wave pulse propagation theory, using an output signal of the optical measuring instrument that measured the acceleration of the other end surface,

wherein the dynamic linearity of the acceleration sensor is obtained by comparing in time domain and frequency domain an output signal of the acceleration sensor when two projectiles are impacted simultaneously or at a prescribed time interval with a sum of acceleration signals obtained from correction calculated signals obtained from the strain gauge when two projectiles are launched separately.

7. A method for measuring dynamic linearity of an acceleration sensor, comprising:

generating an elastic wave pulse in a metal rod (1) by impacting one of end surfaces (2) of the metal rod with each of two round, concentrically located projectiles (8, 10) from a double launch tube (4, 5) independently, and by impacting both projectiles simultaneously or at a prescribed time interval,

using an acceleration sensor (23) provided on the other of the end surfaces (22) of the metal rod to measure an acceleration of the other end surface arising when the elastic wave pulse generated by the impact of the projectiles reflects at the other end surface,

using an optical measuring instrument (24) to measure the acceleration of the other end surface,

measuring strain in the elastic wave pulse produced by the projectile impact at a representative strain gauge (25) location of a plurality of strain gauges affixed axially along a side surface of the metal rod, and

calculating a correction to a strain gauge measurement signal corresponding to wave dispersion and attenuation according to elastic wave pulse propagation theory, using an output signal of the optical measuring instrument that measured the acceleration of the other end surface,

wherein the dynamic linearity of the acceleration sensor is obtained by comparing in time domain and frequency domain an output signal of the acceleration sensor when two projectiles are impacted simultaneously or at a prescribed time interval with a sum of acceleration signals obtained from correction calculated signals obtained from the strain gauge when two projectiles are launched separately.

8. A method for measuring dynamic linearity of an acceleration sensor according to any one of claims 2 to 7, wherein the strain gauge is composed of a plurality of strain gauges provided on a circumference at a same distance from the one end surface of the metal rod, and output signals from the plurality of strain gauges are used.

9. A method for measuring dynamic linearity of an acceleration sensor according to claim 3 or 7, wherein the plurality of strain gauges are provided at a plurality of locations in an axial direction that are provided in a plurality on a circumference at each location at a same distance from the one end surface of the metal rod, and output signals from the plurality of strain gauges are used.

10. A method for measuring dynamic linearity of an acceleration sensor according to any one of claims 1, 6 and 7, wherein the optical measuring instrument comprises a laser interferometer.

11. An apparatus for measuring dynamic linearity of an acceleration sensor, comprising:

a launch apparatus (9, 11) that impacts one of end surfaces (2) of a metal rod with each of two round, concentrically located projectiles (8, 10) from a double launch tube (4, 5) independently and impacts both projectiles simultaneously or at a prescribed time interval to generate an elastic wave pulse in the metal rod (1),

an acceleration sensor (23) affixed to the other of the end surfaces (22) of the metal rod to measure an acceleration of the other end surface arising when the elastic wave pulse generated by the impact of the projectiles reflects at the other end surface,

an optical measuring instrument (24) that measures a velocity of motion of the other end surface and calculates it as acceleration, and

comparison means that compares in time domain and frequency domain an output signal of the acceleration sensor when two projectiles are impacted simultaneously or at a prescribed time interval with the acceleration obtained when two projectiles are launched separately, measured and calculated by the optical measuring instrument (26).

12. An apparatus for measuring dynamic linearity of an acceleration sensor, comprising:

a launch apparatus (9, 11) that impacts one of end surfaces (2) of a metal rod with each of two round, concentrically located projectiles (8, 10) from a double launch tube (4, 5) independently and impacts both projectiles simultaneously or at a prescribed time interval to generate an elastic wave

pulse in a metal rod (1),

an acceleration sensor (23) affixed to the other of the end surfaces (22) of the metal rod to measure an acceleration of the other end surface arising when the elastic wave pulse generated by the impact of the projectiles reflects at the other end surface,

a strain gauge (25) provided on a side surface of the metal rod to measure strain in the elastic wave pulse, and

comparison means that compares in time domain and frequency domain an output signal (26) of the acceleration sensor when the two projectiles are impacted simultaneously or at a prescribed time interval with a sum of acceleration signals obtained from strain gauge measurement signals obtained when the two projectiles are launched separately.

13. An apparatus for measuring dynamic linearity of an acceleration sensor, comprising:

a launch apparatus (9, 11) that impacts one of end surfaces (2) of a metal rod with each of two round, concentrically located projectiles (8, 10) from a double launch tube (4, 5) independently and impacts both projectiles simultaneously or at a prescribed time interval to generate an elastic wave pulse in the metal rod (1),

an acceleration sensor (23) affixed to the other of the end surfaces (22) of the metal rod to measure an acceleration of the other end surface arising when the elastic wave pulse generated by the impact of the projectiles reflects at the other end surface,

a strain gauge (25) provided at a plurality of locations axially along a side surface of the metal rod that measures strain in the elastic wave pulse, and

comparison means that compares in time domain and frequency domain an output signal of the acceleration sensor when the two projectiles are impacted simultaneously or at a prescribed time interval with a sum of acceleration signals obtained from strain measurement signals produced by the acceleration at a representative strain gauge location.

14. An apparatus for measuring dynamic linearity of an acceleration sensor, comprising:

a launch apparatus (9, 10) that impacts one of end surfaces of the metal rod with each of two round, concentrically located projectiles (8, 10) from a double launch tube (4, 5) independently and impacts both projectiles simultaneously or at a prescribed time interval to generate an elastic wave pulse in the metal rod (1),

an acceleration sensor (23) affixed to the other of the end surfaces (22) of the metal rod to measure an acceleration of the other end surface arising when the elastic wave pulse generated by the impact of the projectiles reflects at the other end surface,

a strain gauge (25) provided on a side surface of the metal rod to measure strain in the elastic wave pulse,

calculation means that calculates a correction to a strain gauge measurement signal corresponding to wave dispersion and attenuation according to elastic wave pulse propagation theory, and

comparison means (26) that compares in time domain and frequency domain an output signal of the acceleration sensor when the two projectiles are impacted simultaneously or at a prescribed time interval with a sum of acceleration signals obtained from correction calculated signals obtained from the strain gauge when the two projectiles are launched separately.

15. An apparatus for measuring dynamic linearity of an acceleration sensor, comprising:

a launch apparatus (9, 10) that impacts one of end surfaces (2) of a metal rod with each of two round, concentrically located projectiles (8, 10) from a double launch tube (4, 5) independently and impacts both projectiles simultaneously or at a prescribed time interval to generate an elastic wave pulse in the metal rod (1),

an acceleration sensor (23) affixed to the other of the end surfaces of the metal rod to measure an acceleration of the other end surface arising when the elastic wave pulse generated by the impact of the projectiles reflects at the other end surface,

a strain gauge (25) provided at a plurality of locations axially along a side surface of the metal rod that measures strain in the elastic wave pulse,

calculation means that obtains a representative location measurement signal from a strain gauge measurement signal and calculates a correction to the representative location measurement signal corresponding to wave dispersion and attenuation according to elastic wave pulse propagation theory, and

comparison means (26) that compares in time domain and frequency domain an output signal of the acceleration sensor when the two projectiles are impacted simultaneously or at a prescribed time interval with a sum of acceleration signals obtained from correction calculated signals based on strain gauge measurement signals obtained when the two projectiles are launched separately.

16. An apparatus for measuring dynamic linearity of an acceleration sensor, comprising:

a launch apparatus (9, 10) that impacts one of end surfaces (2) of a metal rod with each of two round, concentrically located projectiles (8, 10)

from a double launch tube (4, 5) independently and impacts both projectiles simultaneously or at a prescribed time interval to generate an elastic wave pulse in the metal rod (1),

an acceleration sensor (23) affixed to the other of the end surfaces (22) of the metal rod to measure an acceleration of the other end surface arising when the elastic wave pulse generated by the impact of the projectiles reflects at the other end surface,

a strain gauge (25) provided at a plurality of locations axially along a side surface of the metal rod for measuring strain in the elastic wave pulse,

an optical measuring instrument (24) that measures a velocity of motion of the other end surface,

calculation means that calculates a correction to a strain gauge measurement signal corresponding to wave dispersion and attenuation according to elastic wave pulse propagation theory, based on an output signal of the optical measuring instrument, and

comparison means (26) that compares in time domain and frequency domain an output signal of the acceleration sensor when the two projectiles are impacted simultaneously or at a prescribed time interval with a sum of acceleration signals obtained from correction calculated signals obtained from the strain gauge when the two projectiles are launched separately.

17. An apparatus for measuring dynamic linearity of an acceleration sensor according to any one of claims 12 to 16, wherein the strain gauge comprises a plurality of strain gauges (25) provided on a circumference at a same distance from the one end surface of the metal rod to use output signals from the plurality of strain gauges.

18. An apparatus for measuring dynamic linearity of an acceleration sensor according to claim 16 or 17, wherein the calculation means calculates

the correction to the strain gauge measurement signal corresponding to wave dispersion and attenuation according to elastic wave pulse propagation theory, based on an output signal of the optical measuring instrument (24), with the acceleration sensor not attached to the metal rod.

19. An apparatus for measuring dynamic linearity of an acceleration sensor, comprising:

a launch apparatus (9, 10) that impacts one of end surfaces (2) of a metal rod with each of two round, concentrically located projectiles (8, 10) from a double launch tube (4, 5) independently and impacts both projectiles simultaneously or at a prescribed time interval to generate an elastic wave pulse in the metal rod (1),

an acceleration sensor (23) affixed to the other of the end surfaces (22) of the metal rod to measure an acceleration of the other end surface arising when the elastic wave pulse generated by the impact of the projectiles reflects at the other end surface,

a strain gauge (25) provided at a plurality of locations axially along a side surface of the metal rod that measures strain in the elastic wave pulse,

an optical measuring instrument (24) that measures a velocity of motion of the other end surface,

calculation means that calculates a correction to a strain measurement signal produced by the acceleration at a representative strain gauge location corresponding to wave dispersion and attenuation according to elastic wave pulse propagation theory, based on an output signal of the optical measuring instrument, and

comparison means (26) that compares in time domain and frequency domain an output signal of the acceleration sensor with a correction calculated signal obtained from the strain gauge.

20. An apparatus for measuring dynamic linearity of an acceleration sensor according to any one of claims 12 to19, wherein the strain gauge comprises strain gauges provided in a plurality on a circumference at each location at a same distance from the one end surface of the metal rod.

21. An apparatus for measuring dynamic linearity of an acceleration sensor according to any one of claims 11, 16 and 19, wherein the optical measuring instrument comprises a laser interferometer.

22. An apparatus for measuring dynamic linearity of an acceleration sensor according to any one of claims 19 to 21, wherein the calculation means calculates a correction to an elastic wave pulse strain signal produced at a representative strain gauge location by the projectile impact corresponding to wave dispersion and attenuation according to elastic wave pulse propagation theory, based on a signal of the optical measuring instrument, with the acceleration sensor attached to the metal rod.

23. An apparatus for measuring dynamic linearity of an acceleration sensor according to any one of claims 11 to 22, wherein the projectile has a laminated structure of different materials.

24. An apparatus for measuring dynamic linearity of an acceleration sensor according to any one of claims 11 to 22, wherein the launch apparatus is a multiple launch tube having inner and outer launch tubes in which a frequency band of the elastic wave generated in the metal rod can be narrowed by launching multiple projectiles from the inner launch tube and controlling a phase of each projectile launch.

25. An apparatus for measuring dynamic linearity of an acceleration sensor according to any of claims 12 to 22, wherein in accordance with a theoretical propagation of the elastic wave in the metal rod, when obtaining transient signal distortion of the elastic wave pulse incident on the other end surface from a strain gauge output signal, at least a primary term of a series-expanded Skalak's solution is used.

26. An apparatus for measuring dynamic linearity of an acceleration sensor according to any one of claims 12 to 22, wherein in accordance with a theoretical propagation of the elastic wave in the metal rod, when obtaining transient signal distortion of the elastic wave pulse incident on the other end surface from a strain gauge output signal, up to a high-order term of a series-expanded Skalak's solution is used.

27. An apparatus for measuring dynamic linearity of an acceleration sensor according to any one of claims 11 to 22, wherein the dynamic linearity of the acceleration sensor is measured by measuring the acceleration of the metal rod end surface and comparing in frequency domain an acceleration sensor input acceleration signal with an acceleration sensor output signal derived from acceleration measurement results, strain gauge measurements or wave propagation theory.

28. An apparatus for measuring dynamic linearity of an acceleration sensor according to any one of claims 11 to 22, further comprising a dynamic linearity calculation means that obtains a difference in timing at which the two projectiles impact the metal rod as a parameter in which a transient acceleration signal input to the acceleration sensor generated when a first projectile impacts the metal rod, and a transient acceleration signal input to the acceleration sensor generated when a second projectile impacts the metal

rod, best match a transient acceleration signal input to the acceleration sensor generated when both projectiles are launched simultaneously, and measures the dynamic linearity of the acceleration sensor from an acceleration sensor output signal obtained when each projectile is launched independently and an acceleration sensor output signal obtained when both projectiles are launched at a prescribed time differential.

29. An apparatus for measuring dynamic linearity of an acceleration sensor according to any one of claims 11 to 22, further comprising a support means that uses point contact that does not hinder rigid motion in an axial direction for supporting the metal rod horizontally.

30. An apparatus for measuring dynamic linearity of an acceleration sensor according to any one of claims 11 to 22, further comprising a metal ball contacted to the metal rod end surface and the projectile launch apparatus launches a plurality of projectiles disposed in a concentric circle from the multiple launch tube and precisely controls the launch timing with respect to the metal ball, to generate an elastic wave pulse in the metal rod.

31. An apparatus for measuring dynamic linearity of an acceleration sensor according to any one of claims 12 to 22, wherein a correction function correcting wave dispersion, wave attenuation, uncertainty of sound velocity value, acceleration sensor mass and gauge frequency response, and the metal rod to which a gauge is affixed, are constituted as a set of essential replacement parts required to match individual acceleration sensors.

32. A method for measuring dynamic linearity of an acceleration sensor according to any one of claims 1 to 7, wherein an inner projectile or outer projectile, or an inner group of projectiles launched from a multiple

inner launch tube, or an outer group of projectiles launched from a multiple outer launch tube, does not depend on a launch sequence.

33. An apparatus for measuring dynamic linearity of an acceleration sensor according to any one of claims 11 to 16 and 19, wherein an inner projectile or outer projectile, or an inner group of projectiles launched from a multiple inner launch tube, or an outer group of projectiles launched from a multiple outer launch tube, does not depend on a launch sequence.